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THE AMERICAN

METEOROLOGICAL JOURNAL.

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HISTORY OF THE WEATHER MAP.*

MARK W. HARRINGTON, CHIEF OF THE WEATHER BUREAU.

[*Abstract.*]

FOR the current weather map two elements were needed, — simultaneous observations and immediate collection of data. The need of absolutely simultaneous observations was recognized early. From 1772 to 1777 Thomas Jefferson and James Madison took simultaneous observations at Monticello and Williamsburgh in Virginia, about one hundred and twenty miles apart. About the same time it appears that the idea occurred to Lavoisier, who proposed (probably before 1784) that instruments for such observations should be scattered over France, Europe, and the world generally, and refers to an earlier proposal of this sort by Borda. Lavoisier prophesied, with wonderful foresight, the successful forecasting of the weather for at least a day ahead by such proceedings as these.

The first renewal of a plan of rapid collection of data which I have been able to find was that of Kreil in 1842. Kreil maintained that the method of aerial telegraphy, previously suggested, was not sufficient, and proposed the use of an electro-magnetic telegraph, about coincident in time with the first experimental test of the telegraph between Washington and Baltimore.

The earliest proposal for a weather map which I have seen was one by Brandes in a letter from Breslau, dated Dec. 1, 1816. Brandes there states that he tried making daily weather maps from newspaper reports and had found them unsatisfactory. He then proposes to get together a service of forty or fifty stations

* Prepared for the Chicago Congress of Meteorology.

and make from their reports a chart for each day of the year. This plan seems never to have been carried out.

It was not until sometime in 1856 that current charts were made of the weather, this being done by the Smithsonian Institution. Prof. Henry's own words on this subject are: — "The first practical application of the principle we have mentioned was made by this institution in 1856; the information conveyed by telegraphic despatches in regard to the weather was daily exhibited by means of different colored tokens, on a map of the United States, so as to show at one view the meteorological condition of the atmosphere over the whole country."

In 1857 Le Verrier began publishing an international bulletin, which he made daily at the beginning of 1858. His first predictions for ports were made in 1860. The synoptic charts were not published by him until 1863. On Sept. 11 of that year he printed and published the isobars and winds for Sept. 7. On Sept. 16, 1863, he printed the weather map for that day, and this has been continued to this day. This was the first current weather map published. It gives daily the isobars and winds for Central and Western Europe.

In 1869 Prof. Cleveland Abbe, with the assistance of the Western Union Telegraph Company, began the collection and use of telegraphic weather reports at Cincinnati; and on Feb. 2, 1870, Mr. Armstrong, local manager of the telegraph company, undertook the making of weather maps and their multiplication by a manifold process. These maps were continued until Oct. 10, 1870. These were the first current weather maps in the United States. The official American system of weather maps began with tri-daily maps, Nov. 1, 1870. They were in manuscript, and were made both at Washington and Chicago. The printing of the morning maps began at Washington on May 2, 1871. The next series of current weather maps was that of the British Meteorological Office. The first appeared in printed form in the bulletin for March 23, 1872. Eighteen current daily weather maps are now issued by the various national weather services. In size the maps vary from 565 mm. by 400 mm. (American) to 98 mm. by 134 mm. (British). In Japan the map is still tri-daily. In America it was formerly tri-daily but is now bi-daily. The Russian maps are bi-daily. The remainder, fifteen in number, are daily, and all, except the Australian, are issued on Sunday.

The hours of observation are: For the United States, 8 A. M. and 8 P. M., 75th meridian time; for Australia, 1 P. M. and 4 P. M.; for Japan, 6 A. M., 2 and 10 P. M., 135th meridian time; for India, 8 A. M.; for Algeria, 7 A. M.; 7 A. M. for Austria, France, Russia (and 9 P. M.) and Switzerland; 8 A. M. for Germany, Italy, Bavaria, Sweden, Great Britain, and Belgium; 9 A. M. for Spain. Forecasts are given on all the maps but the Algerian. A tabular statement is given for a number of stations varying from five on the Belgian to one hundred and thirty on the American and one hundred and thirty-eight on the Russian.

In addition to the bi-daily map issued at Washington, seventy-three stations of the United States issue maps independently, each for a considerable area about the station as a centre. There were thus issued 8,830 daily maps on June 1, 1893, of which 6,257 were issued in the morning and the remainder in the evening.

In addition to the current weather map already noted, there are others, the issue of which is delayed, though they are in all proper senses daily weather maps. Among those the most important are: —

1. The standard weather chart of Australasia, issued by the Queensland Post and Telegraph Department. It is the largest weather map issued, being 23 in. x 18.5 in.

2. Hoffmeyer's "Cartes synoptiques journalières," issued by the Institut Météorologique Danois, and later continued with the assistance of the Hamburg Deutsche Seewarte, first printed for Sept. 1, 1873, and published from three to six years after their date.

3. "Atlas des mouvements généraux de l'atmosphère," issued by the Observatoire Imperiale de France, from June 4, 1864 to December, 1865.

4. Synchronous weather charts, issued by the London Meteorological Council from Aug. 1, 1882, to Aug. 31, 1883.

5. Bulletin of international meteorological observations taken simultaneously, published by the Signal Service from six months to one year after date. Quarto charts were published from Oct. 1, 1877, to Dec. 31, 1884. The maps from Jan. 1, 1885, to Sept. 30, 1886, remained in manuscript. A folio edition was printed separately from July 1, 1884, to December, 1884, and from Oct. 1, 1886, to Dec. 31, 1887.

THE METEOROLOGICAL WORK OF THE MEDICAL DEPARTMENT OF THE U. S ARMY.*

MAJOR CHARLES SMART, U. S. A.

[*Abstract.*]

METEOROLOGICAL science in the United States was conceived and brought forth by the Army Medical Department. General Joseph Lovell, the first Surgeon-General of the army, appointed in 1818, is usually credited with the honor of having instituted the Army Meteorological Service, and every reference to the subject published from the office of the Surgeon-General gives credit to Dr. Lovell. Nevertheless, it appears that Surgeon-General Lovell's credit must be restricted to the fact that he appreciated the value of the existing rules of the Medical Department in regard to meteorological observations. The earliest meteorological journal on file in the office of the Surgeon-General, instead of bearing date January, 1819 (as claimed), is dated at Cambridge, July, 1816, and signed by Benjamin Waterhouse, Hospital Surgeon.

In going back through the Military Laws, Rules, and Regulations of the United States, an order may be found dated May 2, 1814, which makes it a duty of hospital surgeons to keep a diary of the weather. Prior to this date neither the regulations of the army nor the rules of the medical department made any reference to such a duty. Dr. James Tilton, of Delaware, was then the Physician and Surgeon-General of the Army. As the order directing the keeping of a diary of the weather was issued during his administration, the credit of originating it belongs officially to him. The meteorological journal of Dr. Waterhouse gives three observations daily, 7 A. M., 2 P. M., and 9 P. M., of the barometer, thermometer, state of sky and winds, with a column for remarks.

The first results of the work of the Army Medical Department in this direction were given to the world in a volume entitled "Meteorological Register for the years 1822–1825, from observations made by the surgeons of the army at the military posts of the United States," prepared under the direction of

* Prepared for the Chicago Congress of Meteorology.

Joseph Lovell, M. D., Surgeon-General of the United States Army. 8vo. Wash., 1826. The next publication was much more elaborate and embodied the data of the first volume by way of an appendix, in order to present the whole of the observations in one view: "Meteorological Register for the years 1826-1830." 8vo. Phila. 1840. The compilation and able discussion of the results presented in this volume were the work of Assistant Surgeon Samuel Forry, U. S. Army.

When Dr. Forry resigned in 1840, Mr. J. P. Espy became attached to the Surgeon-General's office to collate the meteorological journals and study the steadily accumulating mass of facts. He immediately sent out a circular letter urging the keeping of meteorological journals by voluntary observers throughout the country, by colleges, high schools, naval and light-house stations, etc., on the forms prescribed for the Medical Department, especially requesting co-operation in his efforts to develop the phases of storms. In 1843 he received journals from fifty observers who noted barometer changes, and from sixty others who had no barometer, and in the preparation of his first report to the Surgeon-General he utilized the observations of the months of January, February, and March of that year. In 1851 the third "Meteorological Register" was published, containing the observations from 1831 to 1842. The tables embraced the record of sixty-two posts.

Since 1874 all meteorological reports from army medical officers have been turned over to the Chief Signal Officer, or to his successor in charge of the Weather Bureau.

THE METEOROLOGICAL WORK OF THE SMITHSONIAN INSTITUTION.*

THE SECRETARY, SMITHSONIAN INSTITUTION.

[*Abstract.*]

THE Smithsonian Institution has always made it a rule of action to undertake such lines of work as point the way to great public utilities, and these have subsequently been made the function of useful government bureaus of applied science. This is notably true in the case of meteorology, which was

* Prepared for the Chicago Congress of Meteorology.

developed by this Institution in both its scientific and its popular aspects, until its importance became so well understood that, in 1870, Congress made it the duty of the Chief Signal Officer of the United States Army to observe and report storms for the benefit of commerce and agriculture.

The interest of the Smithsonian Institution in meteorology began with the organization of its work by its first secretary, Prof. Joseph Henry, in 1847. In his "Programme of Organization," submitted on the 8th of December, 1847, in giving examples of objects for which appropriations might properly be made, the secretary mentioned first a "System of extended meteorological observations for solving the problem of American storms." On Dec. 13, 1847, the Board of Regents adopted the "Programme," and on Dec. 18, inaugurated the system of meteorological observations by an appropriation of one thousand dollars for the purchase of instruments and other related expenses. In 1850 the Institution issued its "Directions for meteorological observations"; these were reprinted in 1855 and again in 1870. The first edition of its Meteorological Tables, by Dr. Guyot, was published in 1852, the second in 1857, the third in 1859, the fourth in 1884. A new edition, entirely recast, was issued in 1893.

In 1849 Prof. Henry personally requested the telegraph companies to direct their operators to replace in their regular morning despatches the signal "O. K." by which they were accustomed to announce that their lines were in order, by such words as "fair," "cloudy," etc., thus giving without additional trouble, and as concisely as possible, a summary of the condition of the weather at the different stations, which should be communicated to him. This request was complied with, and such elementary telegraphic weather reports were thus furnished the Institution daily.

With the material thus obtained the Institution was enabled in 1856 to construct the first current weather map, giving daily, from "live data," the meteorological conditions over the whole country. The systematic notification of the general public by the press, and otherwise, of weather observations, appears then to have been undoubtedly due to Henry, and unquestionably to have preceded, by a year, a similar publication in 1858 by Leverrier, to whom this pioneer step has been erroneously attributed.

Among the associates of the Institution in the investigation of meteorological data may be mentioned Prof. Espy, and, later, Prof. J. H. Coffin, Mr. C. A. Schott and others. Their work may be concisely described as follows: Prof. Espy utilized the already collected data in the preparation of his 3d and 4th Meteorological Reports. After the Smithsonian observations were practically completed, Mr. Schott took the data and prepared elaborate tables of temperature and precipitation, which were published in the Smithsonian "Contributions to Knowledge." Prof. Coffin compiled his great work, "On the Laws of the Wind," and contributed various lesser works to the bibliography of the Institution on meteorological subjects.

EARLY INDIVIDUAL OBSERVERS IN THE UNITED STATES.*

ALFRED J. HENRY.

[*Abstract.*]

AT the time of the colonization of America, meteorology was not recognized as one of the physical sciences; its essential instruments had not been discovered, and its votaries had not advanced beyond the loose and fallacious methods that were current during the early centuries. It is not surprising, therefore, that our knowledge of the climate of the pre-instrumental period is limited to such fragmentary notes and references as may be found in the early colonial records, in the reports of explorers, and in various other papers.

The instrumental period in the United States began with Dr. John Lining's observations at Charleston, S. C., in 1738. Prior to that time, systematic observations of the weather had been made and recorded by two observers, although at widely separated periods. The first of these was the Rev. John Campanius, a Swedish clergyman, who kept a daily record or running account of the weather during 1644 and 1645, at Fort Christiana, near the site of the present city of Wilmington, Delaware. Campanius' record is rather remarkable, considering the time and circumstances under which it was made.

* Prepared for the Chicago Congress of Meteorology.

The second observer was the Honorable Paul Dudley, Chief Justice of Massachusetts, who kept a record of the weather at Boston, Mass., in 1729-30.

Eight years later Dr. John Lining, of Charleston, S. C., began the first series of instrumental observations in the United States, of which we have a record. His observations were carefully and accurately made.

Dr. Lining was followed by Dr. John Winthrop, Hollis Professor of Mathematics and Natural Physics, at Harvard College, Cambridge, Mass., in 1742. Dr. Winthrop continued to observe the weather until 1763. He was followed by John Bartram, at Philadelphia, in 1748; Dr. Richard Brooke, in the province of Maryland, in 1753; Francis Fauquier, at Williamsburg, Virginia, in 1760; and twelve years later by Thomas Jefferson at the same place.

At the beginning of the nineteenth century, climatic observations, more or less complete, had been made at Charleston, S.C.; Cambridge, Mass.; Philadelphia, Pa.; in the province of Maryland; at Williamsburg, Va. (also at Monticello, Va.); Bradford, Ipswich, Salem, Charlestown, and Andover, Mass.; New Haven, Conn.; New York City and Albany, N. Y.; Nazareth and Morrisville, Pa.; Rutland, Vt.; Fort Washington, Ohio, and Natchez, Miss. The observations were, as a rule, limited to temperature, rainfall, direction of the wind, state of the weather and the barometer. Fahrenheit's thermometer was generally used. Little was known of rain-gauges and other instruments. Definite conclusions appear to have been reached in some sections respecting the depth of rainfall, the average temperature, the amount of cloud, the direction of the wind, etc., yet the subject of meteorology as a whole was but imperfectly understood.

In 1817 an effort was made by Josiah Meigs, Commissioner of the General Land Office, to have Congress authorize the registers of the several land offices to make meteorological observations. Failing in this, he secured the personal co-operation of a number of the registers on a less elaborate plan, and through private effort obtained a number of climatic records from various other observers. The system thus inaugurated terminated, however, with the death of Meigs in 1822.

STORMS OF THE NORTH ATLANTIC.*

ENSIGN EVERETT HAYDEN, U. S. N.

[*Abstract.*]

"THE Stormy North Atlantic" is the name that its storms have earned for this ocean. Its tropical cyclones and its winter gales are notorious for their ferocity and persistency, and the *northers* and *blizzards* of the American coast are often equalled by the gales of the Bay of Biscay and the *bora* and *mistral* of Southern Europe.

All of its storms are cyclonic in character; that is, broadly speaking, they show the characteristic Northern Hemisphere counter-clockwise circulation of the wind, with barometric pressure below the normal. A chart of the tracks or paths along which such storms travel, and the frequency with which they occur, illustrates very clearly that the Gulf Stream and the Gulf of St. Lawrence are the stormiest regions, and thence extends a broad zone or belt along which the usual winter storms travel across the ocean toward Northern Europe. Another important, though fortunately less frequented, track is that followed by tropical cyclones, or West Indian hurricanes which, originating in the Tropics north of the 10th parallel, move slowly *westward* at first, before their tracks recurve to join the broad and frequented path from the Grand Banks toward Norway and Iceland. These two sets of storms, namely, the winter storms north of the 35th parallel and the tropical cyclones, are the great types of North Atlantic storms. The former are often of enormous extent and great severity, their cold northwesterly gales oftentimes raging continuously for an entire week all the way from Labrador and Nova Scotia to the Azores and Ireland. Within the entire area of the storm the barometric pressure is below the normal, — lowest, of course, near the centre of the great whirl, but notably low throughout. The easterly quadrants of the storm are generally cloudy, with rain or snow and hail; the westerly, clear and cold. To the southward of such a storm centre a secondary whirl often originates, and this vigor-

*Prepared for the Chicago Congress of Meteorology.

ous offspring sometimes excels its parent in energy and strength.

The season for tropical cyclones, or West Indian hurricanes, is from June to October, inclusive, and their normal tracks, though varying somewhat in different months, form great parabolas, concave to the east, with their vertices near the American coast. These storms are *tornadic* in character, — enormous whirlwinds, with towering, ragged, inky cloud-masses on every side of a clear, calm, central space called the *eye* of the storm. The terrific violence of the whirling wind, and the partial vacuum at the centre (indicated by the very low barometer and the very steep gradients) elevate the surface of the ocean, so that the great tornado carries along with it a vast low mound of water, leaping into pyramidal heaps beneath the central calm, lashed into billows of foam and spindrift in the broad annular space around the centre, and sending out huge rollers on every side, to become long, low ocean swells that give warning a thousand miles away of the approaching storm. When this great mound or mass of water, the "storm wave" of the hurricane, is precipitated upon a low-lying coast it causes frightful floods and destruction of every kind.

Thus the West Indian hurricane, with its tornadic winds, its frightful seas, and its storm wave is by far the most dreaded of all North Atlantic storms, and the track along which one has moved on its majestic march from the Tropics toward the pole has seldom failed to be marked out by wrecks and wreckage.

THE CREATION OF METEOROLOGICAL OBSERVATORIES UPON THE ISLANDS SCATTERED OVER THE OCEAN AND CONNECTED WITH A CONTINENT BY CABLE.*

ALBERT, PRINCE SOVEREIGN OF MONACO.

[*Abstract.*]

AFTER many years' experience in the yacht *L'Hirondelle* on the North Atlantic, the writer is convinced of the great value of regular systematic meteorological observations on the islands therein, especially the Cape Verde, the Azores,

* Prepared for the Chicago Congress of Meteorology.

and Bermudas. The prospect that these islands will soon be in telegraphic communication renders the consideration of this project important. These islands are specially suitable and conveniently located for meteorological observations for the following reasons: —

The Cape Verde Islands are situated in a region in which, according to the Pilot Charts, many cyclones originate, thence going to the West Indies and the coast of the United States. They are also located along the exterior border of the circular movement of the North Atlantic waters, whose existence and course the writer's researches upon its currents have shown. The Azores are situated near the centre of this circulation, on which account they deserve special attention, forasmuch as an interesting coalescence exists between that centre and the centre of the area of high oceanic pressure, when the maximum bears to the westward to coincide with that of the Bermudas. The Bermudas are near the western border of the circulation, not far from the Gulf Stream, which plays an important part in the meteorology of the ocean, and under whose influence the Bermudas are.

With these three points at our command, an efficient supervision could be exercised over the North Atlantic. The heights of the mountains on the Cape Verde and Azores (2,974 and 2,321 meters, respectively) also permit observations of the upper regions of the atmosphere, though such annexed observations would, for the present, be of secondary importance in relation to the forecasting of the weather, as the results of the observatory at Ben Nevis show that the observations of the inferior layers are most advantageous for weather forecasting. The observatories at St. Vincent, on the Cape Verdes, at San Miguel, on the Azores, and at the principal islet of the Bermudas, will often be able to collect observations made on vessels at sea one or two days previous to their coming into port.

The value of such observatories has been apparent to the writer for a long time, and, as the prospect of laying the cable to the Azores is now but a question of time, it is submitted for your consideration. This proposition was laid by the writer before the Academy of Sciences at Paris, and the British Association at its session at Edinburgh, in 1892, and on both occa-

sions received favorably. The appeal is made to this Congress to discuss this project, the realization of which is evidence of the propagation of modern civilization. The pecuniary sacrifices necessary to carry this into execution can surely be arranged upon an equitable basis; and if all the great countries unite to defray the expense of maintaining these edifices in the midst of the seas, far from the turmoil of politics and war, a legitimate compensation will be obtained in making the parole of Science hush the voice of cannons.

THE RECURRENCE OF HURRICANES IN THE SOLAR MAGNETIC 26.68 DAY PERIOD.*

PROF. FRANK H. BIGELOW.

THE exceptionally destructive character of the West India and Gulf of Mexico hurricanes of the season 1893 has drawn public attention to this subject, so that it may be desirable to make the following note regarding the periodic occurrence of this type of storms: —

In *Finley's Hand Book of Storm Tracks*, on page 16, for the West India, and on page 19, for the Gulf of Mexico hurricanes, is collected the series of dates upon which these storms occurred, the date given being that of the day of the appearance of the individual cyclones. The list concludes with the year 1888, and is probably nearly complete up to that time, so far as the records have been preserved. This list has been supplemented by an inspection of the daily maps of the United States Weather Bureau, and as these include only such hurricanes as developed at the regular stations of observation, it cannot be as complete since 1888, as in the preceding years. It is my purpose to get an idea of relative frequencies only, and an exhaustive list is not necessary for this object; for the same reason the tabulation begins with 1875, and is throughout limited to the months August, September, and October.

The magnetic ephemeris is constructed from the data, Epoch 1887, June 12.22, period 26.68 days (synodic), the first day of the period being number *one*.

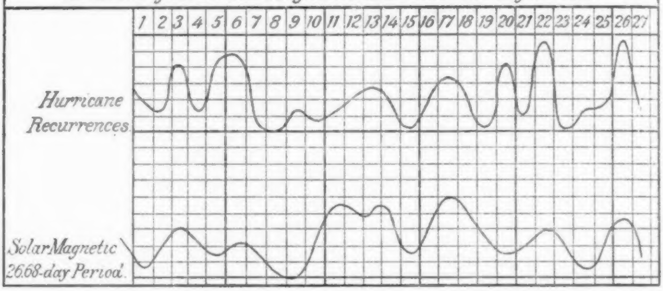
* Communicated by the Author, by permission of the Chief of the Weather Bureau.

The dates in the magnetic ephemeris corresponding to the common dates of observation, given by Finley, were found and tabulated in a twenty-seven day period, those occurring on the same day of the new ephemeris being collected under each other. The following table exhibits the result:—

RECURRENCE OF HURRICANES IN THE SOLAR MAGNETIC 26.68 DAY PERIOD.

1	**2**	**3**	**4**	**5**	**6**	**7**
1882. Oct. 8 1888. Sep. 8 1889. Sep. 16	1879. Oct. 11 1887. Sep. 1	1875. Sep. 9 1875. Sep. 9 1883. Aug. 26 1884. Sep. 3 1886. Aug. 24 1891. Oct. 5	1886. July 30 1887. Aug. 7	1878. Aug. 13 1879. Aug. 22 1883. Aug. 28 1885. Oct. 10 1885. Oct. 10 1886. Sep. 22	1883. Oct. 22 1886. Sep. 23 1887. Oct. 1 1888. Aug. 17 1889. Aug. 25 1889. Sep. 21 1891. Sep. 11	1887. Oct. 29
3	2	6	2	6	7	1
21	14	42	14	42	49	7
8	**9**	**10**	**11**	**12**	**13**	**14**
	1876. Oct. 19 1878. Oct. 10	1885. Aug. 23	1877. Oct. 3 1893. Oct. 2	1883. Sep. 3 1884. Sep. 12 1893. Sep. 7	1886. Sep. 3 1887. Aug. 16 1887. Oct. 8 1892. Oct. 22	1884. Oct. 11 1887. Oct. 9
0	2	1	2	3	4	2
0	14	7	14	21	28	14
15	**16**	**17**	**18**	**19**	**20**	**21**
	1887. Oct. 11 1889. Aug. 8 1891. Aug. 25	1880. Oct. 7 1881. Aug. 23 1883. Sep. 10 1887. Aug. 20 1888. Sep. 24	1882. Sep. 2 1882. Sep. 2 1886. Aug. 13		1877. Sep. 16 1886. Oct. 8 1887. Sep. 19 1888. Oct. 23 1889. Oct. 5 1891. Sep. 25	1887. Oct. 16
0	3	5	3	0	6	1
0	21	35	21	0	42	7
22	**23**	**24**	**25**	**26**	**27**	
1878. Aug. 30 1879. Aug. 12 1883. Aug. 18 1885. Aug. 8 1885. Sep. 30 1886. Aug. 17 1887. Oct. 17 1893. Oct. 13		1883. Aug. 20 1886. Aug. 19	1876. Sep. 12 1888. Aug. 26	1877. Aug. 25 1877. Sep. 22 1887. Sep. 24 1890. Aug. 27 1890. Sep. 23 1890. Oct. 19 1892. Sep. 12 1893. Aug. 28	1882. Sep. 11 1882. Oct. 8	
8	0	2	2	8	2	
56	0	14	14	56	14	

The number of hurricanes on each day is multiplied by the factor seven, in order to give an amplitude to the variations agreeing approximately with the scale on which the variations of the magnetic field are conveniently plotted, which is about fifty millimeters, when a day is denoted by a ten millimeter abscissa.



Comparison of the Recurrence of Hurricanes with the Variations of the Coronal Magnetic Field in the 26.68 day Period.

For comparison, the typical magnetic curve is placed below. It will be remembered that this curve was derived from European data, and represents the variations of the magnetic field surrounding the sun, due to the polarization of its nucleus, which is carried along past the earth, giving a fluctuating intensity to the field impressed upon our polar zones. An inspection of these curves enables one to see their similarity of type, and that they have closely synchronous maxima and minima, the crests falling near the 3d, 6th, 13th, 17th, 22d, and 26th days, as was indicated in my paper (September, 1893, same Journal). The hurricane curve fails chiefly at the 20th day, but when the nature of the data upon which it depends is remembered, this defect is not embarrassing.

The conclusion is necessary that the intensifications of the polar magnetic field (coronal field) have much to do with the generation of these tropical storms. A complete philosophy of the laws of meteorology might be deduced from it, were there not so many points of the subject as yet but partially understood. I will, therefore, content myself now with calling attention to the harmony consisting between this phenomenon and the scheme of atmospheric circulation briefly sketched in the same article.

Two distinct types of radiant energy emanate from the sun, and fall upon the earth in the form of ether vibrations, the one at the equator being quite steady, and that at the poles varying in its intensity with the rotation of the sun on its axis. The former increases the temperature of the atmosphere in the equatorial belt, and disposes a system of streams of air to flow north and northeast towards the pole in the northern hemisphere; the latter decreases the hydrostatic pressure but increases the temperature of the atmosphere around the magnetic pole for the maximum, and *vice versa* for the minimum magnetic intensity, and sets up a system of currents moving south and southwest in the same hemisphere. Both these secondary currents, tending to restore thermal equilibrium, drift eastward in the middle latitudes according to the usual forces derived from the rotation of the earth on its axis. The really valuable fact is this, that these cool currents from the north *start* at the dates singled out by the maximum intensities of the magnetic ephemeris, and in their drift, say across the United States, give rise to much of the weather conditions prevailing at their birth and during their process of development and exhaustion. This proposition appears clearly on the daily weather maps, but the complete exposition of it is retained for the present.

Suppose we select a system of three such currents, A, B, C; A and C cool and moving southward, B warm and moving northward between A and C. The currents A and C generate a westward horizontal component in consequence of their south velocity, while B induces an eastward component by reason of its north velocity. The result is to crush B and C together and pile up the atmosphere into a high area; at the same time A and B are pulled asunder and effect a counterpart low area. Of course these primary results are followed by the well-known vortex motions around these centres. In this way the interchange circulation between the poles and equator is carried on chiefly by surface currents, in which vertical components are merely the result of the secondary vortical motions; and I think this agrees closely with the facts of observation, as might be shown at length.

Therefore, the real cause of the development of tropical hurricanes is the transportation of the cool polar current of air across the United States, pushed well down into the tropics, in August,

September, and October, when the magnetic field first regains its activity after the summer, and while the warm tropical air is still far to the north. When this retires southward beyond the reach of the cold north current, the tendency to produce a hurricane is lessened. This system of winds is plainly shown on the Bulletin of the storm of Oct. 5 to 14, 1893, recently issued by the Weather Bureau.

If a hurricane were fully developed every time a maximum magnetic crest acted upon the polar atmosphere it would be perfectly simple to predict the dates of the occurrence for a long time to come. Unfortunately gaps occur in this series of dates, some being omitted, wherein if such a storm was really begun in the strata above the ground, it attracted no serious attention. Possibly the incomplete traces of such action may be detected by a more direct study of the variations of the barometer and thermometer.

There are, however, certain dangerous or critical hurricane dates when it will be proper for all interested in the subject to be especially watchful. For the year 1894, these will be

August.	1	3	7	10	13	20	24	27	29.
September.	2	6	9	16	20	23	25	29.	
October.	3	6	13	17	20	22	26.		

The following are the most critical dates: corresponding to the

6th day. — August 13, September 9, October 6.
17th day. — August 24, September 20, October 17.
22d day. — August 3, 29, September 25, October 22.
26th day. — August 7, September 2, 29, October 26.

These fourteen dates out of ninety-two days in the three months are liable to be hurricane days, though only three or four may develop to a considerable extent.

WASHINGTON, D. C., Oct. 19, 1893.

A CLOUD-BURST IN ARIZONA.

JOHN D. PARKER.

A VERY remarkable cloud-burst occurred about seven miles west of Fort Bowie, Arizona, Sept. 7, 1890, of which only a partial account has ever been given to the public. It is sel-

dom that the violence of this storm has been equalled in the annals of circular storms, and it is fortunate that such cloud-bursts occur at rare intervals, for they carry destruction in their pathway.

It was towards the close of a clear, sultry day that this cloud-burst, without warning, broke over the Dos Cabezas range of mountains into Sulphur Spring Valley. Mr. Henry Fitch, whose ranch is located near the base of these mountains, was at home that day, and took timely and careful observations of the storm. It passed directly in front of his house, which stands on higher ground, but the deluge of water poured out by the cloud-burst rose rapidly and came within a few feet of his front gate. About 3 P. M. on that day a strange roaring in the mountains, two or three miles away, first attracted his attention. Looking towards the mountains, with apprehension, he saw dense clouds pouring over the peaks, which here rise about two thousand feet above the valley. There was a fearful commotion among the clouds as the storm plunged down into the valley, and a terrible roaring and grinding, probably of rocks, which were hurled down the mountain side in vast masses and scattered over the valley along the path of the storm for two or three miles. There was a sudden condensation of vapor and an immense outpouring of water, and the wind seemed to be irresistible. The cloud-burst appeared to be made up of three strata of clouds, superimposed on one another, the lower red stratum composed probably of dust and *débris* of the storm; the middle, black stratum composed probably of water, and the upper, blue stratum composed probably of vapors in process of condensation. Large trees growing on the sides of the mountain, pine, oak, and walnut, from two to three feet in diameter, were torn up by the roots and hurled bodily down the mountain into the valley. Great quantities of cord wood, which had been cut for the Fort, were also washed down into the valley, and scattered for miles, and ranchers living along the path of the storm used this wood, and that cut from the prostrated trees, for two or three years for firewood. Mr. Fitch says there was a wall of water fifteen feet in height and thirty rods wide that swept down the valley toward the southeast, carrying everything before it.

Fortunately the funnel passed by his house without injuring

it, but there was a sheet of water left in front of his house four hundred feet wide, and in some places thirty feet deep. Pipes conveying water to his house from a spring about a mile distant were washed out for about five hundred feet. Two wells in the path of the storm, one fifty feet deep, were entirely filled up by the boulders so that they could scarcely be found again.

The flood divided about a mile down the valley, and passed on both sides of a house occupied by Mrs. Reese, which was located on higher ground. The cloud-burst was followed by a heavy rainfall, for nearly two hours, and water kept running in the gulch from the mountains for three days. The next day Mr. Fitch rode on horseback twelve miles down the valley to Mr. Rigg's ranch, and his horse waded through water more than three miles of the way.

Dr. Charles Wilcox, U. S. A., surgeon at Fort Bowie, and a lady, were about four miles down the valley, taking a horseback ride. As soon as they saw the storm, they rode at full speed towards the mountains, and escaped the funnel, but the general storm overtook them, and gave them a thorough drenching. Dr. Wilcox thinks the funnel was about a quarter of a mile in diameter, and he saw very vivid lightning playing through it. The doctor noticed a few hailstones during the storm.

Mrs. Major McGregor, wife of the commanding officer at Fort Bowie, was making a little pleasure trip that day, with her children, in Sulphur Spring Valley. When the cloud-burst poured over the mountains, they were about three miles down the valley, riding towards the storm. They turned instantly, and drove at full speed away from the storm, just escaping the funnel, but were soon overtaken by the general storm. Mrs. McGregor is a careful observer, and gives a vivid description of the storm, which surpassed in violence and grandeur anything she had ever witnessed. She says the wind blew fitfully in fearful gusts, at times almost overturning the ambulance. For safety the party at last got out of the ambulance, and lay down on their faces on the ground, covering themselves as best they could with their mackintoshes. Great drops of rain fell, seemingly as large as half dollars. The sun had been shining all day, but the heavens were suddenly filled with black clouds, which were tossed and tumbled about in great confusion. The funnel of the cloud, which passed near them, revolved from right to left with a high

velocity and great violence, and threw off immense volumes of white vapor, which seemed like steam. Within the funnel there was a terrible roaring unlike any thing they had ever heard before. The lightning was incessant and blinding, and the thunder was one constant roar, with loud stunning crashes, now and then, that were deafening. The mules drawing the ambulance were terribly frightened, and were only prevented from running away by the utmost efforts of the driver.

As soon as the funnel passed by them, the party climbed into the ambulance, and drove rapidly homeward. They had not proceeded far when they met the coming rush of waters, which at first ran level with the bottom of the ambulance, but decreased in depth to about two feet, through which the mules waded for three miles, until they reached high ground. Mrs. McGregor says she saw cattle in the distance swimming in the flood.

During the height of the storm the play of the lightning was terrific and blinding, and the thunder very loud. The air seemed to be full of fire, the lightning played around the tires of the wheels of the ambulance in blue flames, while jagged blue flames darted over the prairie. After the storm passed the weather suddenly turned cold, and continued so until the next day. The valley road over which they had driven in the morning was level, but on their return it had been gouged out by the water in places from ten to fifteen feet deep. The party arrived at home thoroughly drenched.

The next summer the writer, while stationed at Fort Bowie, examined the path of this storm, and found the valley where it had passed strewed with boulders of every imaginable variety, size and shape, from rocks probably weighing two or three tons down to minute fragments. The stones evidently were not deposited in geological times, to be laid bare and brought to view after the soil was washed away by the storm, as stones are often left in the bed of a creek, for Sulphur Spring Valley elsewhere is composed of a sandy, porous soil remarkably free from boulders. The boulders were undoubtedly transported from the mountains and deposited on the prairie by some post-geological force, which has left them in piles and rows, sometimes heaping them up two or three feet above the general surface of the valley. Ranchers living in the vicinity of the path of the storm confirm this fact, and agree that there were no stones

visible in the valley before the cloud-burst. The road leading up Sulphur Spring Valley to Mr. Fitch's ranch was so obstructed by rocks deposited by the cloud-burst that the ranchmen opened a new road some distance from the former track, leading around the field piled with rocks. In some places the stones are strewn along in lines, as if they had been collected to be built into a wall, and in one locality they look at a little distance as if they were a wall, the illusion only disappearing after an examination. In one place several acres are completely covered with these boulders, as if they had been tumbled out of the funnel all together.

The rocks are composed of different materials, massive in character, and some of them must weigh a ton. My attention was particularly attracted by a massive rock that measures five feet long, three and a half feet wide, and rising above the surface two and a half feet. It is firmly imbedded in the soil, but how far it extends below the surface no one knows. Ranchers compute its weight at five tons, but I gave it a moderate estimate of about one half that weight. The transportation of such a massive rock from the mountains two miles over the prairie shows the dynamic force of these storms. I noticed in one place an excavation made by the water, about eight feet wide and ten feet deep. It was evidently considerably deeper at first, — ranchers say fifteen feet deep.

The writer has made a faithful attempt to describe this cloud-burst, but no one, without experience, knows how difficult it is to construct the history of such a storm a year after its occurrence.

CURRENT NOTES.

The New Anemometer and Temperature Station on the Obir. — In the August number of the *Meteorologische Zeitschrift*, Dr. Hann had an illustrated article on the new meteorological station on the summit of the Obir. The Hoch Obir is a mountain in the Austrian province of Carinthia, in Lat. 46° 30′ N., and Long. 14° 27′ E. of Greenwich, and rises to a height of 2,140 meters above the sea. A meteorological station was established on this mountain, 100 meters below the summit, in 1846, and observations have been made there, with some breaks, continuously ever since down to the present time. In this JOURNAL, Vol. II., 1885-86, pp. 500-504, Mr. Rotch gave an account of the Obir station and of the results of its observations. The observations were made by the mine overseers until the mines were abandoned in 1875. In 1876 and 1877 no records were kept, but in August, 1878, they were recommenced, a regular observer being appointed by the Austrian Meteorological Society. The station was later made one of the first order by the addition of a barometer (in 1879), and some registering instruments (in 1880-81), this being accomplished through the energetic efforts of Dr. Hann. In September, 1883, an anemometer was erected on the actual summit, 2,147 meters above the sea, and a sunshine recorder was added to the equipment in the same year.

An account of the station in winter, by Dr. J. M. Pernter, illustrated by a fac-simile of a drawing taken from nature, may be found in the *Met. Zeitschr.*, Vol. XX., 1885, pp. 353, 354. The observations made on the Obir have been very fully and ably discussed in a series of articles as follows: Dr. J. M. Pernter, "Einige neuere Resultate der meteorologischen Beobachtungen auf dem Obirgipfel," *Met. Zeitschr.*, XIX., 1884, 331-336; "Beitrag zu den Windverhæltnissen der hœheren Luftschichten," *Sitzungsberichte der Wiener Akademie*, XC., Abth. II. July, 1884; "Taeglicher Gang der Windgeschwindigkeit auf Berggipfeln," *Met. Zeitschr.*, XX., 1885, 140-142; "Die Taegliche Periode der Windrichtung auf dem Obirgipfel und dem Saentis," *Ibid*, 175-180; "Die Windverhæltnisse auf dem Sonnblick und einiger anderer Gipfelstationen," *Denkschriften der Wiener Akademie*, LVIII., Wien, 1891; Dr. Hann, "Die thermischen Verhæltnisse der Luftstrœmungen auf dem Obir," *Sitzungsberichte der Wiener Akademie der Wissenschaften*, LVI., December, 1867, and LVII., May, 1868. The observations are published every year in the "Jahrbuch der K. K. Central Anstalt für Meteorologie."

Dr. Hann's present paper deals with the new station on the summit of the Obir, and with some of the most recently obtained results. The old station was not a summit station, as it was 100 meters from the top of the

mountain, and was sheltered to the north and west by higher mountain tops. Moreover, the thermometer had to be exposed on the southern side of the building, owing to the proximity of the northern side of the house to the mountain. Further, the position of the anemometer on the actual summit was not all that could be desired, as the instrument was partially protected by the mountain top. For these reasons it was determined to build a new house on the summit, and the so-called "Hann-Warte," was opened on Oct. 10, 1891, in the presence of a representative of the Austrian Meteorological Society and others. In recognition of the valuable services of Dr. Hann, the new observatory was called by his name. Dr. Hann himself visited the station in September, 1892.

The new anemometer building is on the highest summit of the Obir, and is raised on a foundation one meter in height, which itself reaches one meter into the ground. It is surrounded by a gallery. The house is built of wood, and is placed exactly according to the four cardinal points of the compass, its shape being that of a square, but with flattened corners. The sides are each two meters long. The roof is three meters above the gallery, and the anemometer cups are about one meter above the roof, so that the height of the anemometer above the ground is about five meters. The registering apparatus of the anemometer is inside the building. The entrance is on the south. On the north side there is a window, and in front of this, in a shelter freely open to the air, are a Richard thermograph and a thermometer. The thermograph is 1.7 meters above the gallery, and 2.7 meters above the ground. The exposure of the thermograph is excellent. As the summit slopes off steeply on all sides, there can be hardly any influence on the temperature records by radiation from the warmed surface of the peak. The Obir itself rises up above the range of mountains of which it is a part. It is over 1,700 meters above the Drau valley on the north, and 1,600 and 1,500 meters above the valleys to the east and south. The nearest equally high summits are Kosuta, to the southwest, 10 kms. distant, Petzen, to the east, 20 kms. distant, and Grintouc, to the south, 17 kms. distant. The northern horizon is unobstructed.

Temperature records were begun on the summit on Feb. 10, 1891, the readings of the thermograph being checked by observations of the thermometer. The results, to February, 1892, inclusive, have been published by Dr. Hann in the *Sitzungsberichte der K. Akademie der Wissenschaften*, Vol. CII., July, 1893, under the title "Der tægliche Gang der Temperatur auf dem Obirgipfel (2,140 m.) und einige Folgerungen aus demselben." The daily range of temperature differences between the station on the summit and the one 100 meters lower for one year shows that in August and September the difference was 2.5° C., and 2.6°C. about 2 P. M., and the mean of the months 0.1° C. and 1.2° C. The diurnal temperature curve on the Obir shows very small amplitudes, and is almost identical with that on the Sonnblick, although the daily amplitude is greater on the Obir in summer. The hourly values of the vertical decrease of temperature between the Obir and the Sonnblick show, during most of the year, hardly any diurnal range, the vertical decrease of temperature being practically constant. Only in summer is there a daily range of slight amount. The mean seasonal decrease of temperature,

between the lower and upper Obir Stations is as follows: Winter, 0.25°; Spring, 0.18°; Summer, 0.76°; Autumn, 0.80°; Year, 0.66°.

As regards the results at the lower Obir station, it is found that the mean minimum temperature for the years 1879–92, is —20° .8 C. The lowest temperature noted was —26° .9 C., in January, 1869. The yearly precipitation has varied from 1,835 mm. in 1885 to 1,193 mm. in 1890. The greatest daily precipitation was 90 mm. on Oct. 4, 1882. More than half of the annual precipitation comes as snow. Winter is the least cloudy season, January having the minimum. Spring has the greatest amount of cloudiness, the maximum coming in April. There is a second minimum in July and a second maximum in October. 8 to 9 A. M., in July, is the sunniest time during the year. In November, December, and January, there is most sunshine between noon and 1 P. M., and after these months the hour of maximum sunshine comes earlier and earlier. In March, 10 to 11 A. M. is the sunniest hour; from April to August the hour is 8 to 9 A. M.; in September it is 9 to 10, and in October, 10 to 11. The afternoon hours in summer have less sunshine than the morning hours owing to the formation of clouds and fog over the peaks towards noon. The Obir shows a very rapid decrease of sunshine after 10 A. M., and a marked increase after 1 P. M., especially in July. The Sonnblick does not show this. On the Obir the cloud cap rises above the peak after 1 P. M. and disappears, but on the high summits of the Tauerngebirge the clouds remain on the peaks during the afternoon. February and August have the most sunshine, according to the length of their days, and April and June have the least. The Obir has over thirty-seven per cent of its possible sunshine. The annual range of wind velocity shows a maximum in December and a minimum in June. The prevailing wind is southeast.

Dr. Hann's article is illustrated by two excellent views of the new "Hann-Warte" and of the lower station, and also of the mountain from the east.

The late H. F. Blanford. — The following notice of the late H. F. Blanford is from the "Report on the Administration of the Meteorological Department of the Government of India for 1892–93," compiled by Mr. John Eliot, M. A., Meteorological Reporter to the Government of India: —

"The Department has to regret the death of Mr. Blanford, its organizer and first director, during the past year. Mr. Blanford came over to India in the Geological Department. After some years' service in that department he was appointed to the Bengal Education Department and became Professor of Physics in the Presidency College, Calcutta. His attention was shortly afterwards directed to meteorological problems, more especially the cyclonic storms of the Bay of Bengal. The great Calcutta cyclone of October, 1864, showed the urgent necessity for the introduction of some arrangements for issuing storm warnings to the port of Calcutta. A small system was established under the control of a Meteorological Committee appointed by the Government of Bengal, but the whole of the work was mainly, if not entirely, carried out by Mr. Blanford, who was then Hon-

orary Secretary. Shortly afterwards, when a provincial meteorological system was sanctioned for Bengal, Mr. Blanford was appointed Meteorological Reporter to the Government of Bengal. He devoted all his spare time to his meteorological work, and, in addition to the various official reports, he wrote a series of papers on meteorological subjects, the majority of which were published in the Bengal Asiatic Society's Journals. The most important written during this period, 'The Winds of Northern India,' was read before the Royal Society and published in the 'Philosophical Transactions.' Meanwhile the views of Gen. Strachey and Mr. Blanford, as to the necessity of the adoption of uniform methods of observation over the whole of India, and of the subordination of the provincial meteorological departments already established to a central controlling authority, began to influence government, and eventually it was determined to form an Indian Meteorological Department. Mr. Blanford was directed by the Government of India to draw up a scheme for its establishment in 1874. His proposals were accepted, and he was in 1875 appointed director or Meteorological Reporter to the Government of India, which post he held until his retirement in May, 1887. During this period there was a steady expansion of the department on the lines laid down in his original proposals. His first important publication as Meteorological Reporter to the Government of India, was the 'Indian Meteorologist's Vade-Mecum,' which was the first text-book of meteorology based on the modern conceptions of the physical sciences. The first half contained a full description of the instruments in use at observatories and the proper methods of observation, and the second part an interesting account of all the more important features of Indian meteorology so far as then known, and their scientific explanation. This book has been described by an American meteorologist as 'the first of the treatises which introduces us to some of the ideas of the modern school of dynamical meteorology. It was for many years the best treatise on modern meteorology in any language.' Shortly afterwards the first number of the 'Indian Meteorological Memoirs' was issued. During his fifteen years' tenure of the directorship, he wrote a large number of papers for the memoirs, in addition to the Annual Reports, and also occasional papers on meteorological subjects published chiefly in the Bengal Asiatic Society's Journal and the Royal Society's Proceedings and Transactions. The most important of these were the monograph on the 'Rainfall of India,' forming Vol. III. of the Indian Meteorological Memoirs, and a paper on the connection of the Himalaya snowfall with dry winds and seasons of drought in India. He took furlough for twenty-one months in May, 1887, and at its expiration retired from the service. The Government of India, in its review of the Administration Report of the year 1888–89, acknowledged his services in the following terms: —

'In conclusion, I am to take this opportunity to record the high estimate which has been formed by His Excellency the Governor-General in Council of the zeal and ability displayed during the several years of his incumbency of the office of Meteorological Reporter to the Government of India by Mr. H. F. Blanford, who has now retired from the service, and who was practically the founder of systematic and uniform observations in India.'

"Mr. Blanford after his retirement continued to work as enthusiastically as before at his favorite subjects. He wrote a popular exposition of the meteorology of India, 'The Weather and Climates of India,' in which he utilized the whole of the results obtained during his *regime*. It is written in an interesting and attractive manner, and is the first work of its kind for a large tropical area. He also undertook, at the request of the Government of India, to discuss the series of hourly observations taken at his instance during the years 1876–87, with a view to accumulate data of the diurnal oscillations of the barometer and their relations to the variations of temperature, humidity, and wind. He had finished about half this work when he was obliged reluctantly to discontinue it on account of failing health. An operation which he underwent effected a short temporary improvement. He died at Folkestone on the 23d of January, 1893.

"The chief result of his labors is that we possess a far better knowledge of the weather and climate of India than of those of any other tropical country, and in some respects better than those of many parts of Europe. His work as an investigator, as well as the administrator of the Indian Meteorological Department, gave him a prominent place amongst meteorologists, and it was a matter of the greatest satisfaction to him that the value of the work done by his department was fully recognized by the leading meteorologists in Europe and America."

Meteorology and the Farmer.— In the August number of the "Cosmopolitan," Col. S. E. Tillman, U. S. A., has a short article entitled "Meteorology and the Farmer," which, owing to the continued misapprehension regarding the production of "artificial rain," deserves reprinting in this JOURNAL: —

"In only one other branch of science have there been greater advances since 1850 than in meteorology. Especially is this so as regards the motions of the atmosphere which bring about our rain and snow-storms, the cyclones, terrific tornadoes, and remarkable cloud-bursts. While the progress has been extraordinary and the advances of the utmost importance, the spread of knowledge upon this subject among the people has hardly begun. This fact is forcibly illustrated by the number of charlatans parading as rain-doctors in the rich but arid regions of the west, where, if newspaper reports are to be relied upon, they have occasionally succeeded in perfecting contracts with the entire population of a county. Less than two years ago the government sent out its own rain experimenters and one of the great magazines published a duet entitled, 'Can we make rain?' one of the writers being the government's chief rain-producer and the other an astronomer of world-wide repute. In this discussion the cause of general rains was referred to an agency recognized and declared as inefficient by recent meteorology. The general principles involved in great rain-storms are well understood by modern meteorologists and cannot fail to interest and be of use to every reader of The Cosmopolitan.

"When moisture-laden atmosphere, from any reason, ascends sufficiently, the pressure to which it is subjected is diminished, it expands and is thereby cooled and its moisture condensed. When this condensation takes place

with sufficient rapidity it rains or snows, otherwise only clouds are produced. *Clouds* may be produced in other ways, but not *rain*. The ascent of the air which produces rain is generally brought about in one of two ways: first, if the prevailing winds blow over high mountains, they will, in the passage, be deprived of their moisture. Thus are produced the heaviest annual rain-falls of the earth. Second, when the atmosphere over any portion of the earth's surface becomes warmer or lighter than over the surrounding areas, it ascends just as the air does in a hot chimney, and in the same manner, too, it draws in the adjacent air and the whole is carried aloft to be expanded, cooled, and deprived of its moisture, with great liberation of heat, which heat keeps the draught in operation.

"In this way are produced all the general rains of the eastern United States. The air over nearly all the region east of the Mississippi is often involved in the same storm. In such storms, flowing from all sides toward the central flue, the air is swerved to the right by the earth's rotation, and the whole becomes involved in one great whirling mass, the central portion ascending as it circles around the flue. These large revolving storms are the cyclones of the meteorologist. Their width is many hundred times their height. When the height of a storm is great as compared to its width, and the velocity of the circling winds very great, it becomes a tornado; these the papers commonly call cyclones, but improperly so. The ordinary thunderstorm is much less severe than a tornado and much less extended than a cyclone. From these well-established facts of modern meteorology it is readily understood how inefficient are any means yet employed to imitate nature's storms. In a very moist atmosphere it might be possible to produce draught enough for a little rain. In the arid regions of the west the moisture is not present to continue the draught even if begun, and no one who thoroughly understands the causes of rain-fall would be willing to attempt it. The idea that cannonading, or any other sounds, can produce rain is absurd in the highest degree. The unfortunate farmer throws away money when he gives it to a rain-doctor."

The late Dr. Carl Lang. — The death of Dr. Carl Lang, Director of the Bavarian Weather Service, was briefly noted in the December number of this Journal. From an appreciative notice of Dr. Lang in the October number of the *Meteorologische Zeitschrift*, prepared by his colleague, Dr. Fritz Erk, the following facts are taken: Dr. Lang was born in Regensburg, on October 10, 1849, and prepared himself at the University of Munich for the teaching of mathematics and physics. His careful work as assistant and as *Privatdocent* in physics at the Technical High School, led to his appointment as assistant in the central office of the Bavarian meteorological service, which was established in 1878, under the direction of Dr. von Bezold. Together von Bezold and Lang organized and established the Bavarian weather service, and von Bezold has often said that he could never have carried out this work so rapidly without the strong and effective support of Dr. Lang.

Dr. Lang's chief work was in connection with the publication of the results obtained by the Bavarian service, in the *Jahrbuch* of that ser-

vice. He also published numerous climatic notes in the monthly summaries, and gave particular attention to the dissemination of the forecasts, and to the education of the public in this connection. His investigation concerning the climate of Munich led to his appointment as *Docent* at the University of Munich, and his work "*Ueber den säkularen Verlauf der Witterung als Ursache der Gletscherschwankung*," attracted much attention.

In 1885, von Bezold was called to Berlin to assume the directorship of the Prussian Meteorological Institute, and Dr. Lang succeeded him as director in Munich. The continued direction of the work of the Bavarian weather service was supplemented by an extension of the thunderstorm investigation, in which Lang was especially interested, and to which he gave a great deal of attention. The secular periodicity of lightning and hail, and the variations in the amount of precipitation, and in the level of ground-water, were other matters on which he did much careful and valuable work. Scientific ballooning was also a subject in which he was interested. Dr. Lang's health began to fail perceptibly during the winter of 1892–93, and he died on Sept. 23, of an affection of the lungs.

Dr. Lang was a member of the Austrian Meteorological Society, of the German Meteorological Society, and of the Munich "Verein für Luftschifffahrt." He was also president of the International Conference of Meteorologists, held in Munich in 1891, and a member of the permanent international meteorological committee. His death has removed one of the most careful and earnest workers in meteorology in Europe.

On Rainmaking. — Dr. Alexander Macfarlane, Professor of Physics in the University of Texas, has written a paper entitled "On Rainmaking," which was read before the Texas Academy of Science on Dec. 31, 1892, and printed in the Transactions of that Society. Prof. Macfarlane has followed the rainmaking experiments in his State closely, and is therefore in a position to know exactly what was actually accomplished by the rainmakers. He reviews briefly Mr. Aitken's famous results in connection with dust and condensation, and also the various schemes for making rain proposed by Espy, Powers, Ruggles, and others. Dyrenforth, whose name is now known all the world over in connection with artificial rain, made an attempt to produce rain artificially at San Antonio, Texas, in November, 1892. Of this attempt Prof. Macfarlane says: "Suppose we take a cubic mile of the air upon which Dyrenforth operated on the night of Friday, Nov. 25, 1892. The record at the weather office in San Antonio at 8 P. M., gave the temperature of the air as 72° Fahrenheit, and the dew point at 61° Fahrenheit. To cool down a cubic mile of that air to the dew point would require the abstraction of as much heat as would raise 88,000 tons of water from the freezing point to the boiling point. To cool it down another eleven degrees would require as much more heat to be abstracted. The amount of water set free would be 20,000 tons, which spread over a square mile would give about 1.4 pounds per square foot, or twenty-seven one hundredths of an inch of rainfall. The amount of latent heat set free by the condensation of that amount of water would raise 100,000 tons of

water from the freezing point to the boiling point; and it would be necessary to absorb this heat in order that the rainmaking might go on. I have supposed the cubic mile of air to be kept constant; if the air operated on is constantly changing, the task becomes one of infinitely greater difficulty. . . . The test of Friday was made while the atmosphere was threatening to rain; 8 balloons, 150 shells, and 4,000 pounds of rosellite were fired off; result, an explosion of a balloon inside of a black cloud does not bring down a shower. The test of the following Wednesday was made with a clear sky; 10 balloons, 175 shells, and 5,000 pounds of rosellite were fired off; result, the sky remained clear."

Annual Report of the New Jersey Weather Service. — The Annual Report of the New Jersey Weather Service for the year ending Oct. 31, 1892, is at hand, and shows an encouraging condition of affairs during the year. The number of meteorological stations has been increased from forty-eight to fifty-eight, and the volunteer corps of the State Service iucludes eighty crop correspondents, fifty forecast display stations, and nineteen frost warning stations. Forecasts are also sent to a large number of railroad stations through the co-operation of the various railroads. The New Jersey Service was permanently organized by the passage of "An act to establish a Weather Service in New Jersey," approved April 7, 1892. During the year five hundred copies of the bulletin have been issued each month from the Central Office, and one thousand five hundred crop bulletins were issued each week. It is encouraging to note that in New Jersey, as elsewhere, the publications of the Service are more and more appreciated by the people.

There is no direction in which more good can be done in the way of increasing public interest in meteorology than in giving the scholars in the public schools some instruction in this science. Much has been done in this line in many States, and New Jersey is doing her share in the work also. A letter from Prof. G. C. Sonn, Professor of Natural Science in the High School at Newark, printed in this report, illustrates the interest taken by the pupils in the subject, and the benefits derived from the work. Some of the older pupils help directly in taking observations, but almost all are intensely interested in the maps and forecasts. At the end of each month the columns of figures are added up by the scholars, and there is considerable friendly rivalry between the classes as to which shall obtain the correct figures first. Prof. Sonn declares that he has known youths to materially improve in their school duties owing to the discipline which came from their daily and accurate reading of the instruments. He believes that observation of correct instruments checks the tendency to exaggeration as to extremes of heat and cold, so common among all classes of people. Prof. Sonn's letter is certainly a very encouraging one, and furnishes an additional argument in favor of teaching meteorology in the schools.

Annual Report of the Meteorological Department of the Government of India. — The Annual Report of the Indian Meteorological Department for

1892–93 shows an encouraging condition of affairs in that admirable service which has done so much for the science of meteorology. The large amount of inspection of the different stations has had a marked effect in the improvement in the condition of the stations. In 1890–91, 6 were in a "very satisfactory" condition, and 46 were classed as "satisfactory"; in 1891–92, 18 were "very satisfactory" and 26 "satisfactory," while in 1892–93, 43 were reported "very satisfactory" and 18 "satisfactory"; 130 rain-gauge stations were established during the year in the larger provinces in British India. Much work has been done in the department of Marine Meteorology, and the valuable results obtained have been made use of in the publication of a daily report and chart of the whole Indian land and sea area, the first chart having been issued in May, 1893. The forecast of the probable character of the rainfall during the southwest monsoon of 1892 accorded well with the actual facts of precipitation. An interesting use of the weather forecasts was made in the case of a military expedition in the field during the month of January, daily forecasts being sent for the information of the general in command of the forces. Storm warnings and flood warnings were also issued with success.

The Indian service issued during the year a daily weather report and chart, a weekly weather report, and a monthly weather review. Three hundred and fifty copies of the daily weather map were issued each day. The Calcutta office issued the daily weather report and chart of the Bay of Bengal, the Bengal daily, weekly and monthly weather reports, a summary of the monsoon rainfall of 1892, and a general report on the meteorology of Bengal for 1891. Among publications to be issued during the present year are the following: "The Relation between Sun-Spots and Weather as shown by Meteorological Observations taken on board Ships in the Bay of Bengal during the Years 1855 to 1878," by W. L. Dallas; "Investigation into the Mean Temperature, Humidity and Vapor Tension Conditions of the Arabian Sea and Persian Gulf," by W. L. Dallas; and "Discussion of the Hourly Observations at Chittagong," by the late H. F. Blanford. No. V. of the Cyclone Memoirs has lately been issued, and two other volumes have just come to hand, viz.: Part VIII. of Volume IV. of the Indian Meteorological Memoirs, containing an account of the more important cold weather storms in India during the years 1876–1891, by John Eliot, and Part III. of Volume V. of the Memoirs containing a discussion of the hourly observations taken at Dhubri and Roorkee, by the late H. F. Blanford.

The Monsoons of Ceylon.—In *Nature* for June 22, 1893, Mr. E. Douglas Archibald had a short article on The Big and Little Monsoons of Ceylon. The summer monsoon is ushered in by two periods of rain-burst, the first (*chota barsât*) occurring sometimes in April or May; the second (*burra barsât*) in June or July, the time varying with the locality and with the year. The *chota barsât* is probably produced in the same way as the second rain-burst, but the conditions are on a smaller scale and more local than in the second case. In the case of the little monsoon it has been recently maintained that the distribution of temperature anomalies in the Indian Peninsula

regulates its beginning and that of its accompanying *chota barsât*, while the general monsoon is produced by the warming up of the central Asian plateaux, resulting in an inflow beyond the Himalayan barrier. An examination of the records of the dates of commencement of the little and big monsoons at Ceylon, from 1853 to 1892, shows that the average dates are April 20 and May 19, the big monsoon following the little monsoon in about a month. A further examination of the dates of arrival of the big monsoon and of the mean rainfall of the Carnatic shows a remarkable correspondence. When there is a plus anomaly of rainfall in the Carnatic the monsoon comes before its average date, and when there is a minus anomaly the monsoon comes after its average date. Further, it is found that variations in the dates of arrival of the big monsoon correspond to similar variations in sunspot maxima and minima.

The little monsoon is found to show similar relations, commencing early in years with increasing sunspot numbers, and late in years with diminishing sunspot numbers. The period between the dates of commencement of the little and big monsoons varies likewise, the mean maximum interval, forty-three days, corresponding to the years of sunspot minima, and the minimum, twenty days, occurring two years after that of sunspot maxima. The importance of such relations in forecasting the character of the seasons in India is manifest.

Additional Titles of Papers read at the Chicago Congress of Meteorology:—

SECTION A.

1. On the Construction of Air Thermometers to replace the Ordinary Alcohol and Mercurial Thermometers.
   Dr. A. Sprung, Potsdam.

SECTION B.

1. Thunderstorms of Mauritius.
   Charles Meldrum, Mauritius.
2. Thunderstorms of North China.
   S. Chevalier, Zi-Ka-Wei.
3. Signs Preceding Typhoons in the Philippine Islands.
   F. Faura, Manila.
4. Thunderstorms in Canada.
   R. F. Stupart, Toronto.
5. Thunderstorms in New Zealand.
   Sir James Hector, Wellington.
6. The Daily Period of Rainfall in Würtemberg.
   Dr. K. Mack, Stuttgart.
7. Thunderstorms in Jamaica.
   Maxwell Hall, Jamaica.

SECTION C.

1. Brief Sketch of the Climatic Conditions of Denmark.
   Adam Paulsen, Copenhagen.
2. The Climate of the City of Mexico.
   M. Barcena, Mexico.
3. Brief Sketch of the Climate of the Malay Archipelago.
   Van der Stok, Batavia.

SECTION H.

1. Method Employed in France for Announcing Floods.
M. Babinet, Paris.

Uruguay Meteorological Society. — The Uruguay Meteorological Society was established in February, 1891, for the purpose of supporting the Meteorological Service of Uruguay, starting new observatories, contributing towards the study of the climate of that country, and to the progress of meteorology in general. The second volume of the Monthly Review of the Society began with the number for January, 1893, these bulletins containing the usual data as to pressure, temperature, humidity, wind direction and velocity, rainfall and cloudiness. The number of observers is as yet very few, only six regular stations reporting the above-mentioned data for the month of September, 1892. The number of rainfall observers is, however, larger, thirty having kept records during July, 1892. The energetic Director of the Society, Dr. Francisco A. Lanza, is doing his utmost to increase the number of observers, and, although the financial condition of the country is decidedly against the growth of this work, he is hopeful for the future.

The Climate of Quito. — In the *Zeitschrift der Gesellschaft für Erdkunde zu Berlin*, Vol. XXVII., 1893, Dr. Hann has a valuable paper on the climate of Quito. Until lately there have been but very few meteorological data from Ecuador, the accessible material in this connection being very small in amount. Dr. Hann has brought together all the available observations, and on these he has based his results. Among the points of interest brought out, may be mentioned the characteristically tropical occurrence of thunderstorms at Quito. Thunderstorms occur on nearly every third day in the average for the year. April and May are the months of most frequent thunderstorms, and October comes next. The October thunderstorms are described as being the most severe. They occur regularly a little after noon, last about an hour, and are followed by a clear evening and night. The diurnal growth of clouds on the mountains is well marked, the clouds beginning to form about 9 A. M., increasing till noon, finally covering all the peaks, and resulting in thunderstorms about noon. As regards cloudiness, two thirds of the days are entirely cloudy, and one third are clear. Rain is least frequent in the morning and evening, and most frequent at noon. In the principal rainy period, from March to May, there are hardly six clear afternoons in ninety-two days. The winds at Quito are local mountain and valley winds. In the morning the wind is always from south to east-southeast; in the evening, northeast. Real storms do not seem to occur at Quito, although the thunderstorms and the day breezes sometimes attain great violence.

Dr. Hann's conclusion as to the climate of Quito is, that the mean temperature and the changeable weather of that district, with the frequent afternoon thundershowers, are like the weather of Northern Europe in May, and he therefore thinks that the claim of "perpetual spring," which has been made for the climate of Quito, is well based.

CORRESPONDENCE.

CAUSES OF RAINFALL AND SURFACE CONDITIONS.

An answer to Mr. Geo. E. Curtis's paper on Analysis of the Causes of Rainfall with Special Relation to Surface Conditions in this Journal for October, 1893.

Editor of the American Meteorological Journal: —

Meteorologists, at least in Europe, are not only now adopting the opinion that dynamic cooling is the most important cause of rainfall. Hann stated this with clearness in 1874*, and, so far as I know, he did not meet with contradiction. Blanford's greatest merit in this case is to have proved that the more copious rainfall of the Indian monsoon comes with small cyclones. Previously only the large destructive cyclones of India were known to meteorologists.

I do not quite concur in what is said of the *equatorial rain belt.* It is not a calm belt. As to the Amazon region, the east winds (trades) blowing up the river are strong enough, at least in the lower and middle valley, and frequently in the afternoon there are short but violent storms, dangerous to small craft. If it is calm or nearly so in the valleys of the tributaries it is because they are protected from the east winds by the dense forests. If the latter were cut down the winds would have free play. As to the Malaysian Archipelago, I will but mention the "white squalls" in the Malacca Strait. They are strong enough. As to how deforestation would affect the evaporation of such now densely wooded regions, I think firstly by letting the water run off the surface faster than it does now, as gullies and ravines would be sure to arise. The rainfall is by no means in excess over evaporation or the needs of a luxuriant vegetation everywhere in the equatorial belt; *e. g.*, on Baker Island, in the Pacific, nearly under the equator, the rainfall is very scanty.†

On the island of S. Thome', 0° 20′ N., near the west coast of Africa, July is quite rainless, and June to December have but 55 mm. (2 inches) of rain. The Battalands in Sumatra (1° to 3° N.), which are devoid of large forests, and mostly covered by savannas, are exposed to a strong, dry wind (S. E.), which sometimes blows for weeks, doing great harm to vegetation. This Rosenberg says of the vicinity of Ft. Pertibée. (1° N. 100° E).‡

The east coast of Africa under the equator is also rather dry.

**Entstehung der Niederschlaege.* Zeitschr. Oest. Ges. Meteor., 1874, 289.

† Silliman's Journal, 1862. Zeitschr. Oest. Ges. Meteor., 1880, 120.

‡ Malayischer Archipel., 16.

Mr. Curtis puts Upper Assam into the equatorial rain belt while it is situated even outside of the Tropics (27° to 28° N.); yet, its forests resemble the equatorial ones, as well as the constant heat and moisture of the warmer months. I ascribe this to the dense forests.

The classification of rainfall as *convective*, *orographic*, and *cyclonic* is excellent in Mr. Curtis's paper, and the terms ought to be adopted by meteorologists. It is important to have short, clear terms to explain the different conditions in which rain falls. I heartily concur in what the author says of the San Joaquin valley in California, and the probable human agency in increasing the rainfall in the valley and on its slopes. I have already mentioned a case on a larger scale, Japan, with its rice fields in all the plains and valleys, filled with muddy waters intensely heated by the sun, and thus evaporating much.

A. WOEIKOF.

UNIVERSITY, ST. PETERSBURG, Oct. 6, 1893.

BIBLIOGRAPHICAL NOTES.

CYCLONE MEMOIRS NO. V.

JOHN ELIOT, M. A., CYCLONE MEMOIRS, NO. V. *Account of Three Cyclones in the Bay of Bengal and Arabian Sea during the month of November,* 1891, *viz., the Port Blair Cyclone of* 1*st to* 7*th; the Minicoy Cyclone of* 1*st to* 3*d, and the Cyclone of* 19*th to* 23*d.* 8vo, Calcutta, 1893, 186 pages, XXV. plates.

There is no one country which presents so many features of interest to meteorologists as India, with its diversity of climates, its well-known monsoons, and its frequent and often severe cyclones over the Bay of Bengal and the Arabian Sea. For over fifty years the meteorologists of India have published data relating to the storms and other climatic features of that country, until our knowledge of Indian meteorology is to-day as complete, or nearly as complete, as that which we possess concerning the meteorology of many parts of Europe and North America. Piddington, Willson, and Chambers have all done valuable work in India, and since 1875 the Meteorological Department of the Government of India, first under the leadership of Blanford, and now under that of his successor, Eliot, has published a long series of memoirs and records. The "Indian Meteorological Memoirs" and the "Cyclone Memoirs" are the titles of two important series of publications, the first containing records of the meteorological features of different districts, and the second relating to the cyclonic storms of the Bay of Bengal and Arabian Sea, which the Meteorological Department has issued since its establishment. The latest publication, which has just come to our desk, is No. V. of the "Cyclone Memoirs," prepared by Mr. Eliot. While it is impossible for us, on account of lack of space, to adequately review this valuable work, we wish to point out a few of the more important facts it sets forth.

Cyclone Memoirs No. V. contains an account of three cyclones which occurred in the Bay of Bengal and Arabian Sea during November, 1891, and all of which presented several peculiar features. The first storm, called the "Port Blair cyclone" for the sake of convenience, originated in the Gulf of Siam, outside the Indian area, on Oct. 29 and 30, and is the first large cyclonic storm of the bay for which there is clear and conclusive evidence that it originated outside the bay area. It was very severe, the winds being of extraordinary violence and the destruction of life and property very great. Its path in the Bay of Bengal was peculiar. On Oct. 30 and Nov. 1 and 2, its course was west-northwest, curving through northwest to north on Nov. 3 and 4, and then to northeast and east-northeast on Nov. 5. In consequence of this recurvature several ships encountered the storm twice in their

passage up the bay. The origin of this cyclone in the Gulf of Siam, an occurrence only recorded three or four times since 1737, has led Mr. Eliot to modify a statement he made in his "Hand-Book of Cyclonic Storms in the Bay of Bengal." The original statement was to the effect that "All cyclonic storms in the Bay of Bengal originate or are produced in the bay itself." Now, however, he prefers to say: "Cyclonic storms in the Bay of Bengal almost invariably originate in the bay, but under exceptional circumstances of rare occurrence they may enter it from the Gulf of Siam and the Malayan Peninsula."

The circumstances of the origin of this storm were probably as follows: "The storm originated in a sea area which had been characterized by a moderate deficiency of pressure for some time previously, due to peculiarities in the set of the bay monsoon current and the consequent distribution of rainfall. Temperature conditions were probably normal in the area, and the chief feature was uniform temperature with very slight diurnal range. Winds were probably very light, but a humid current continued to blow towards it across the south of the bay. A rise of pressure in Southern India checked the advance of the current to that area, and thus determined it more largely, if not chiefly, to this area. It thus became an area of local concentrated rainfall and of squally weather which developed into a cyclonic storm." The evidence, therefore, is that this cyclone, like similar cyclones beginning in the Bay of Bengal, originated in a small area of concentrated and torrential rainfall. There seem to have been no marked variations of the mean temperature from the normal in the Malay Peninsula or the Gulf of Siam. The cyclone was of low elevation, as it was rapidly broken up when its course directed it across Bengal. Mr. Eliot believes that the whole motion was restricted to the lower ten thousand or fifteen thousand feet of atmosphere.

Some interesting facts relating to the calm centre, or so-called "eye of the storm," are presented in this account. The cyclone passed centrally over Port Blair, and there are barometric records from Port Blair Observatory and from the Norwegian bark "Safir," which was anchored during the storm in a harbor about four miles west of the observatory. The curves obtained differ considerably. The barometer at the Port Blair Observatory is a Casella's Fortin, which has been in use some time and is thoroughly reliable. Moreover, Mr. Carroll, the observer there, is an experienced and intelligent man. The barometer on the "Safir" was an aneroid, an instrument which experience has shown to be frequently untrustworthy. The pressure curves obtained from these records, and illustrated in Plate XVII., differ greatly in form. In the "Safir" case the barometer fell rapidly in the earlier stages of the storm and was almost steady during the period of hurricane winds, rising much more rapidly as the storm withdrew from Port Blair than it did during its approach. The curve as a whole is very unsymmetrical. The Port Blair curve resembles in all its important features the pressure curves of stations over which the calm centres of severe cyclones have passed in India, such as the False Point cyclone of October, 1885 (see this JOURNAL, Vol. IX., page 77), and the Midnapur cyclone of October, 1874,

("Hand-Book of Cyclonic Storms in the Bay of Bengal," Pl. XXVII.). The duration of the calm centre at Port Blair was recorded as fifteen minutes, which gives a breadth, in an easterly and westerly direction, of between four and five miles. The centre also passed over False Point on Nov. 5, between 4.05 and 4.45 P. M., and data regarding this passage have been obtained from the observer at the False Point Light-House and from the Port Officer, the two places of observation being six and one half miles apart. The barometers were a Cassella's Fortin and an aneroid. The curves from these two records are plotted on plate XVIII. The greatest diameter of the calm centre at the light-house was between five and six miles. The lowest pressure recorded was 28.012 in. The features of the calm centre, as far as indicated by the observations at False Point and Port Blair, are as follows: The pressure was lowest at some little distance in front of the calm area. The air was practically if not absolutely calm within the calm area proper. The transition from the hurricane winds in front to the central calm was not sudden but gradual. The sky at False Point during the passage of the centre "was covered with broken cloud, and there was a heavy bank to eastward." The mercury column did not pulsate in the calm area as it did outside of it in the area of hurricane winds and fierce gusts. A noteworthy feature of this storm was the existence of small subsidiary whirls as part of the larger general disturbance, indicated by sudden shifts of wind and oscillations of the barometer noted by several observers.

The second storm originated on Nov. 1 and 2, in the sea area between the Maldives and the Travancore coast, over which region light variable winds had prevailed for some days previously. Very heavy rain fell in this area on Oct. 31 and Nov. 1, and a cyclonic whirl began to form in the area of the heaviest rainfall on the latter day. The cyclone moved westward on Nov. 2, and, passing to the northward of Minicoy during that night, advanced over a part of the Arabian Sea rarely traversed by ships and, therefore, no further information as to its progress could be obtained. The predominant feature of this cyclone was the excessive local or concentrated rainfall, this being the greatest on Oct. 31 and Nov. 1, while the storm was generating. and, therefore, it immediately preceded and accompanied the formation of the storm. The records of the tidal observer at Minicoy show that cyclonic storms of this kind are of rare occurrence at or near Minicoy, and this fact bears out the inference, based on theory and experience, that cyclonic storms are almost unknown nearer to the equator than 8°.

The third storm originated in the southeast of the bay on Nov. 19 and 20, under the normal conditions of storm generation in November. Variable unsteady winds prevailed to the west of the Nicobars, and southwest of the Andamans, previous to the birth of the storm. In this area the weather then became squally, with heavy rain, and on Nov. 19 and 20 the cyclonic whirl was formed. It advanced northwards, recurved to the northeast on Nov. 22, and advanced by a curved path to Central Burma. It was disintegrated by the Arakan Hills, ranging from 1,500 to 3,000 feet in height, a shallow residual depression, which disappeared in twenty-four hours, alone passing the hills.

In concluding this summary of Mr. Eliot's valuable memoir we shall quote a few sentences from the author's statement as to the conditions of origin of these storms. Mr. Eliot says: "The three storms were all generated under similar circumstances. They were all disturbances in the humid southwest monsoon current. They all originated in sea areas under the influence of that current. They each formed during periods when the current was weak and had withdrawn temporarily from the land area of Southern India. The areas in which they formed were the northern or eastern limits of that current, and were, for some days previous to the generation of the storms, areas of light variable winds. Northeast winds prevailed in the sea areas to the north and west, but these winds, as well as those of the southwest monsoon current, were light and feebler than the normal of the period. It is hence almost certain that the origin of these storms was not due to any mechanical action between two opposite air currents. The temperature conditions of the sea areas in which the storms originated, so far as they are indicated by the available observations, were almost certainly normal and very uniform, and it is hence very probable that these storms were not the development of temperature disturbances. . . . It is evident that rainfall or aqueous vapor condensation formed by far the most important factor in determining the origin and motion of the three storms. . . . Cyclones in the months of October, November, and December originate in the intervals known as breaks in the retreating southwest monsoon rains in Southern India, and hence when the current is feeble. The usual antecedents are uniform pressure and temperature conditions in the bay, the prevalence of light and variable winds over a large portion of the bay, and of feeble to moderate unsteady southwest winds in the south of the bay. Fine clear weather usually obtains, and hence evaporation under a tropical sun proceeds rapidly. Frequently, after these conditions have continued for some little time, weather becomes showery and slightly disturbed in a portion of the area; usually that in which winds are lightest and most unsteady and variable. The rainfall increases in amount and becomes more localized and concentrated, and the weather becomes squally. If the conditions favor the continued concentration of the rainfall, the disturbance passes beyond the diffused irregular stage of squally weather and a regular cyclonic circulation is established. The whole of the changes are such as may occur in consequence of the ordinary dynamical changes constantly in progress in the atmosphere. The potent factor in the bay is the aqueous vapor condensation, and any conditions that favor the peculiar distribution of rainfall essential for the initiation or development of the area may be determining conditions."

We should be tempted to enter somewhat fully into the consideration of the different classes of storms in India, of their characteristics and of the theories as to their origin, had not this JOURNAL so recently contained an article on this subject. We would, therefore, refer those who desire further information in this connection to Mr. S. M. Ballou's article on "The Storms of India," Vol. IX., pp. 260–267, 299–307, and also to the paper by the same writer, on "The Eye of the Storm," Vol. IX., pp. 67–84, 121–127.

THE COLD WEATHER STORMS OF INDIA.

JOHN ELIOT, M. A. *An Account of the more important Cold Weather Storms in India during the Years* 1876–1891. Indian Meteorological Memoirs, Vol. IV., Part VIII. Fol. Calcutta, 1893, pp. 530–873; plates LVI.–LXXI.

The interest of most persons in studying the storms of India seems naturally to centre in the cyclones of the Bay of Bengal, those more or less violent whirling storms which occur at the changes of the monsoons, and have become well-known all over the world through the destruction which they have wrought on shipping, and through the storm waves which they frequently raise over the low-lying shores at the head of the bay, resulting in the drowning of thousands of the inhabitants. These storms have been very thoroughly studied by the Indian meteorologists; and Eliot's "Handbook of Cyclonic Storms in the Bay of Bengal," the Indian "Cyclone Memoirs," and other works have given very full and accurate descriptions of them. These cyclones, which, when once formed, are the fiercest storms of the tropical seas, are, perhaps, more attractive subjects for study than others which are less violent; just as the West Indian hurricanes, which frequently come up the eastern coast of the United States in the late summer and autumn, are more interesting to the general public than the great number of more moderate cyclonic storms which cross our country throughout the year with remarkable regularity to the number of two or three a week.

There is, however, another class of storms in India, of more moderate character, which is of great interest for several reasons. This class includes the cold weather storms of northern India. These occur during the prevalence of the northeast monsoon, and chiefly during the cold weather months of December, January, and February. They are formed over the land at its coldest season, instead of originating over the warm Bay of Bengal, as is the case with the cyclones of the transition period, just referred to, and correspond quite closely with the ordinary cyclonic storms of the United States and Europe. They are, therefore, of great interest, partly on account of this resemblance to our ordinary storms, but still more because of the light a study of their mechanism throws on the theory as to the origin of such cyclonic storms in general.

In the work which is the subject of this brief notice, Mr. Eliot, the present efficient Meteorological Reporter to the Government of India, gives a valuable account of all the more important cold weather storms which have been noted in India during the years 1876–1891, and draws many interesting and noteworthy conclusions from his investigation. The greater part of the volume is taken up with a description of the origin, progress, and general characteristics of these storms, with a table giving a summary of their most important features. The last chapter is devoted to a discussion of the chief features of these storms, and is a careful and concise synopsis of the subject. It would be impossible to enter into detail as to the many interest-

ing points here brought out, and we must content ourselves with noting only a few of the more notable facts.

As has been stated above, the winter storms of Northern India differ very widely in all their important features from the cyclones of the Bay of Bengal. The majority originate in northwestern India, but a considerable proportion form in and advance from Beluchistan, and a smaller proportion seem to advance from Central Persia into Beluchistan and thence into northwestern India. A careful study of cyclonic tracks has brought the author to the conclusion that these cold weather storms of India are not the continuation of depressions which have previously affected Europe. Most of these storms are double disturbances, consisting of a primary and a secondary depression. The air motion at the level of the plains accompanying primary depressions is almost always feeble and irregular, not showing the usual well-marked cyclonic indraught characteristic of a strong cyclonic circulation. The evidence from the air motion at the plains stations of Northern India is, therefore, to the effect that the cyclonic circulation is poorly developed, and that local conditions are sufficient to modify it to a very large extent. Further, the facts that land winds continue on the Bombay and Bengal coasts during the whole or the greater part of the existence of these storms, and that the easterly winds when they occur are almost invariably light winds, leads to the conclusion that the latter have little or nothing to do with maintaining the cyclonic circulation and contributing to the energy of the storms. The source of the aqueous vapor condensation and rainfall is therefore limited to an upper current of the atmosphere. This is further borne out by the fact that when these storms reach the Himalayan stations they almost invariably give rise to stronger winds than usual.

These storms are preceded by a warm wave, which is about twenty-four hours in advance of the centre, and are followed by a cold wave, similar to those so common on the rears of our winter cyclones in the United States, which, in India as in our own country, accompanies the advance of northwesterly winds. These cold waves in India are evidently due to the descent of air from the mountain areas of Beluchistan, Afghanistan, and the Himalayas, and advance as a thin stratum over the earth's surface, being generally too shallow to surmount the western Ghâts.

The question of precipitation in these storms is one of very great economical importance, as the snowfall of the Himalayas occurs chiefly during their existence, and the cold weather wheat crop of Northern India depends largely upon the amount and distribution of their rainfall. The precipitation is greater in double than in single disturbances ; occurs chiefly in the northeast and east quadrants, and usually increases in amount northwards to the foot of the hills. A total snowfall of forty to fifty feet in the middle ranges and interior districts of the western Himalayas is by no means uncommon. The paths of these storms lie in a general east-southeast direction across Northern India, and their rate of progression averages three hundred and fifty miles a day. There is a tendency to slight differences from year to year in the mean track of these storms, and the peculiarities in the tracks of any season are fairly persistent throughout the season. The number of storms varies from two to four a month to only one or two in a whole season.

Mr. Eliot's first and most important inference regarding these storms is that they are phenomena of the upper atmospheric currents over Northern India, which is based on the following facts: 1. The feeble cyclonic circulation at the level of the plains, whereas it is strong and well marked at the Himalayan hill stations. 2. The barometric changes are frequently actually as large at the hill stations (7,000–11,000 ft.) as at the level of the plains, and hence, relatively to the actual pressure, greater at those stations than on the plains. 3. Observations of clouds indicate that the lower level of these clouds in the earlier stages is above 15,000 feet, and sometimes about 20,000 feet, and it is probable that in the open plains of India condensation and formation of clouds occur at even higher elevations than over the hills, and hence at an elevation of at least 12,000 feet, and probably above 15,000 feet. 4. The chief precipitation occurs not in the plains but in the hill districts, the rain and snowfall increasing with elevation up to at least 20,000 feet. These storms differ in this respect from those of the southwest monsoon, when the heaviest precipitation occurs between 3,000 and 5,000 feet. Therefore, it appears that the winter cyclonic precipitation is due to forced ascensional motion at a high elevation over the Himalayan area, and not to the ordinary, or normal cyclonic motion over the whole storm area or in the eastern quadrant of the area. 5. These storms appear never to cross the Himalayas; their chief seat of motion and action is therefore probably below the summits of those mountains. They are regarded by Mr. Eliot as large whirls in the upper current over India, this conclusion being based on the uniform direction of their movement, the correspondence in direction of their movement with that of the direction of this upper current; the correspondence of their rate of progression with that of the velocity of this current, and the uniform rate of their movement. The difference in direction between the path of the storms and that of the upper current may very likely be due, in part at least, to the influence of the Himalayas.

India, with its variety of climates, is certainly one of the most interesting regions of the world for the meteorologist to study. As its Bay of Bengal cyclones are attractive on account of their violence and the graphic descriptions we have of them, so the winter storms of Northern India are attractive because they resemble our cyclonic storms so closely, and yet occur in a region which, besides having the phenomena of characteristic extra-tropical cyclones, yet is distinguished also by having the tropical seasonal rainfall due to the southwest monsoon during the summer as well as by its tropical cyclones over the adjacent sea areas. The present volume is a most valuable addition to the already long list of notable works by Indian meteorologists.

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